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# The role of lateral strength variation in the lithosphere in intra-plate compressional deformation: an experimental approach

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich
PGP

E. Calignano[1], D. Sokoutis[1,2], E. Willingshofer[1], C. Thieulot[1,3] & J.P. Burg[4]

(1) Department of Earth Sciences, Utrecht University, PO Box 80021, 3508 TA Utrecht, The Netherlands (2) Department of Geosciences, University of Oslo, PO Box 1047 Blindern, N-0316 Oslo, Norway Physics of Geological Processes, University of Oslo, Sem Saelands vei 24, 0316 Oslo, Norway Geologisches Institut, ETH-Zürich and Universiteit Zürich, Sonneggstrasse 5, 8092 Zürich, Switzerland

**Contact: E.Calignano@uu.nl**

## *INTRODUCTION*

Lateral variation of strength in the lithosphere has been proved to be an important factor controlling the localization of the onset of intra-plate deformation. Pre-existing heterogeneities in the lithosphere can become reactivated both in extension and compression, governing the spatial and temporal development of intra-plate deformation.

Lithospheric scale analogue models investigating the deformation pattern and topography development characterizing compressional intra-plate settings are presented.

The modelled lithosphere consists of a three-layer brittle-ductile rheological structure (brittle crust/ductile crust/weak ductile mantle) and has been deformed in normal gravity field.

Models have been implemented with the presence of a "disturbance zone" (DZ) located either in the ductile mantle or in both ductile crust and mantle and striking perpendicular to the compression direction.

The vertical location and rheology (weak zone vs. strong zone) of the heterogeneity have been the main investigated parameters.

The modeled lithosphere is characterized by a relatively weak ductile crust and mantle and strong decoupling between the brittle and ductile domains.

Presence and location of the DZ and relative lateral strength contrasts within the lithosphere have been the main investigated parameters.

A spectral analysis has been carried out on the elevation profiles by means of a Lomb Transform (a Discrete Fourier Transform for unevenly sampled data).

| MATERIALS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| Layer | Material | Density ρ (kg m-3) | Viscosity η (Pa s) | Stress exponent n | Material constant A |
| Upper crust | dry feldspar sand | 1300 | | | |
| Lower crust | silicon mix I | 1352 | 3,33E+04 | 1,08 | 2,00E-05 |
| Lithospheric mantle | silicon mix II | 1578 | 3,47E+04 | 1,14 | 1,00E-05 |
| Weak Zone | silicon mix III | 1555 | 9,75E+03 | 1,30 | 1,00E-05 |
| Strong Zone | silicon mix IV | 1555 | 4,00E+04 | 2,00 | 1,00E-07 |
| Lower lithosphere | Polytungstae+glycerol | 1600 | 1,20E+00 | | |

Table 1: Material parameters

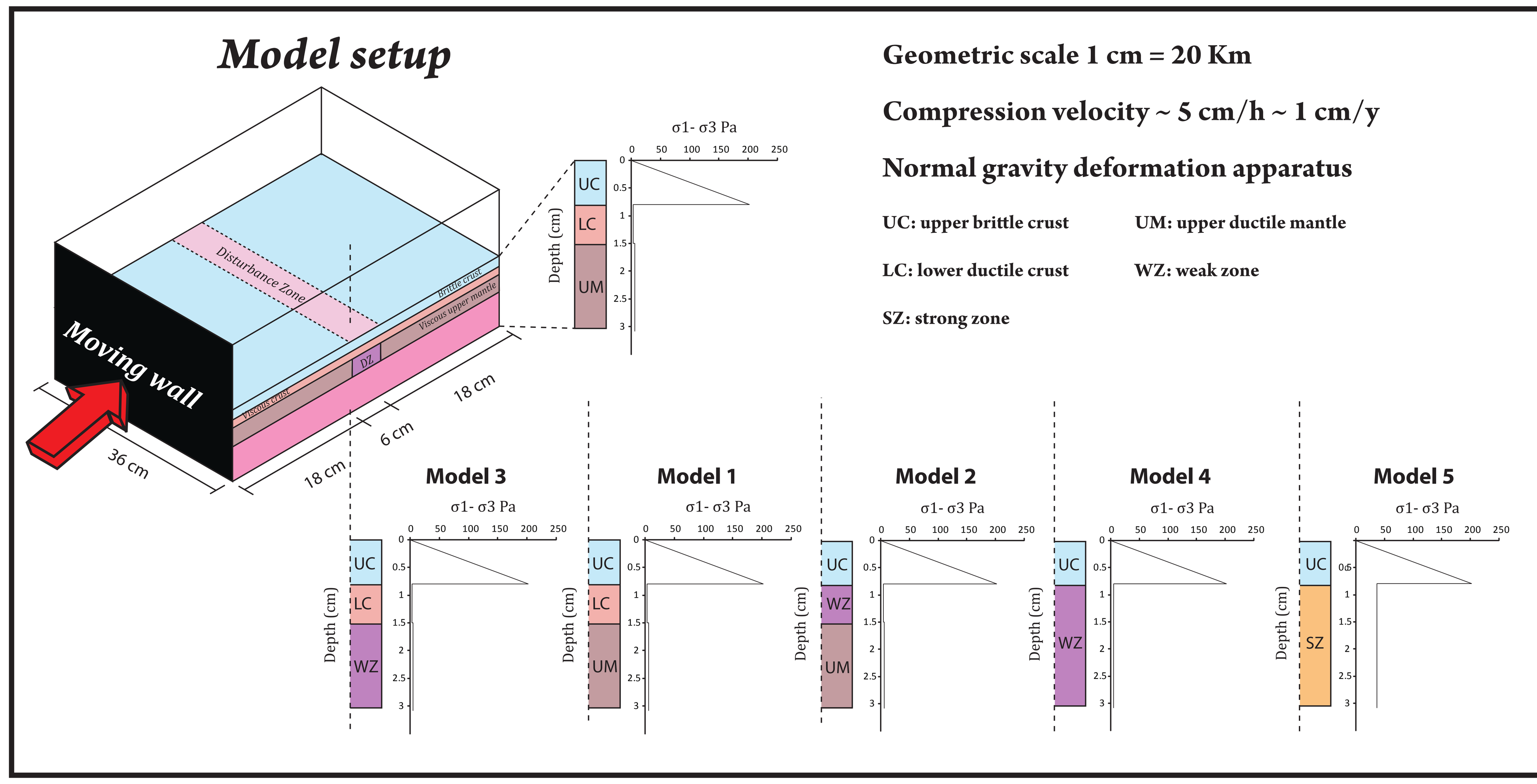



Figure 1: Model set-up and strength profiles showing lateral strength contrasts in the modeled lithosphere.

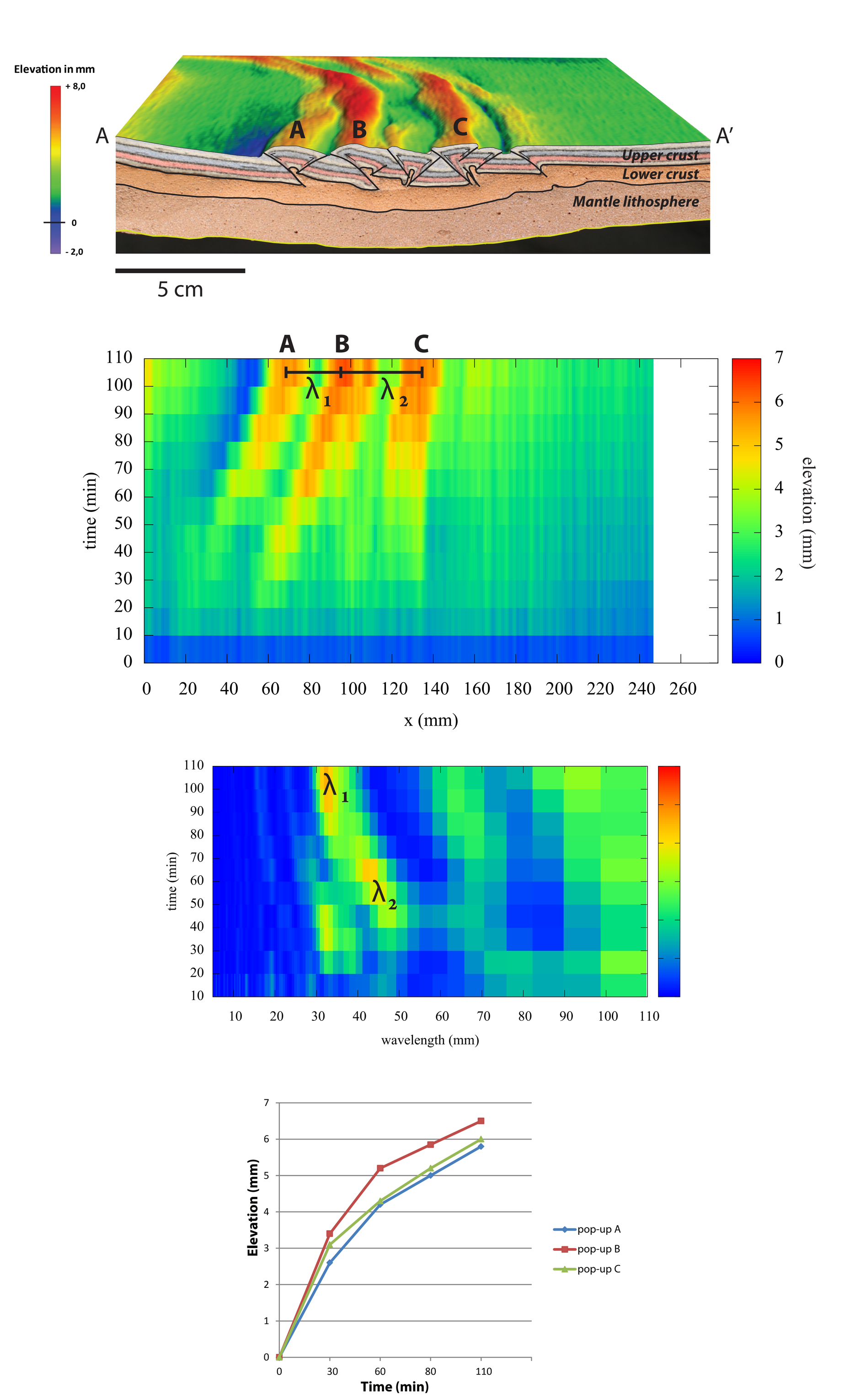
## *CONCLUSIONS*

- The presence of lateral strength heterogeneities in the lithosphere affects the deformation pattern in compressional settings
- In the absence of a disturbance zone ( Model 1) the deformation history of a relatively weak lithosphere is characterized by early occurrence of pop-up and pop-down structures in the central part of the model. There deformation remains localized, in correspondence of a broad synform developed in the ductile part of the lithosphere
- A small strength contrast between a WZ or SZ and the surrounding blocks ( Models 2, 3, 4 & 5) results in a) localization of the deformation at the WZ boundaries and b) an undeformed region with flat Moho in correspondence to the disturbance zone, despite its vertical location and rheology
- The presence of a SZ in the centre of the modeled lithosphere ( Model 5 ) results in a later activation of its right boundary with respect to Model 4 where the disturbance zone is weaker than the sorrounding blocks
- Distribution of pop-up and pop-down structures in the brittle crust appears to correlate with the position of synforms in the ductile lithosphere.
- From the spectral analysis of topography is not always possible to infer the geometry of the lithosphere in depth; major detected wavelengths infact don't correspond to the width of the WZ/SZ despite from the models cross sections the link between this zone and localization of deformation is clear.

## *MODELING RESULTS*

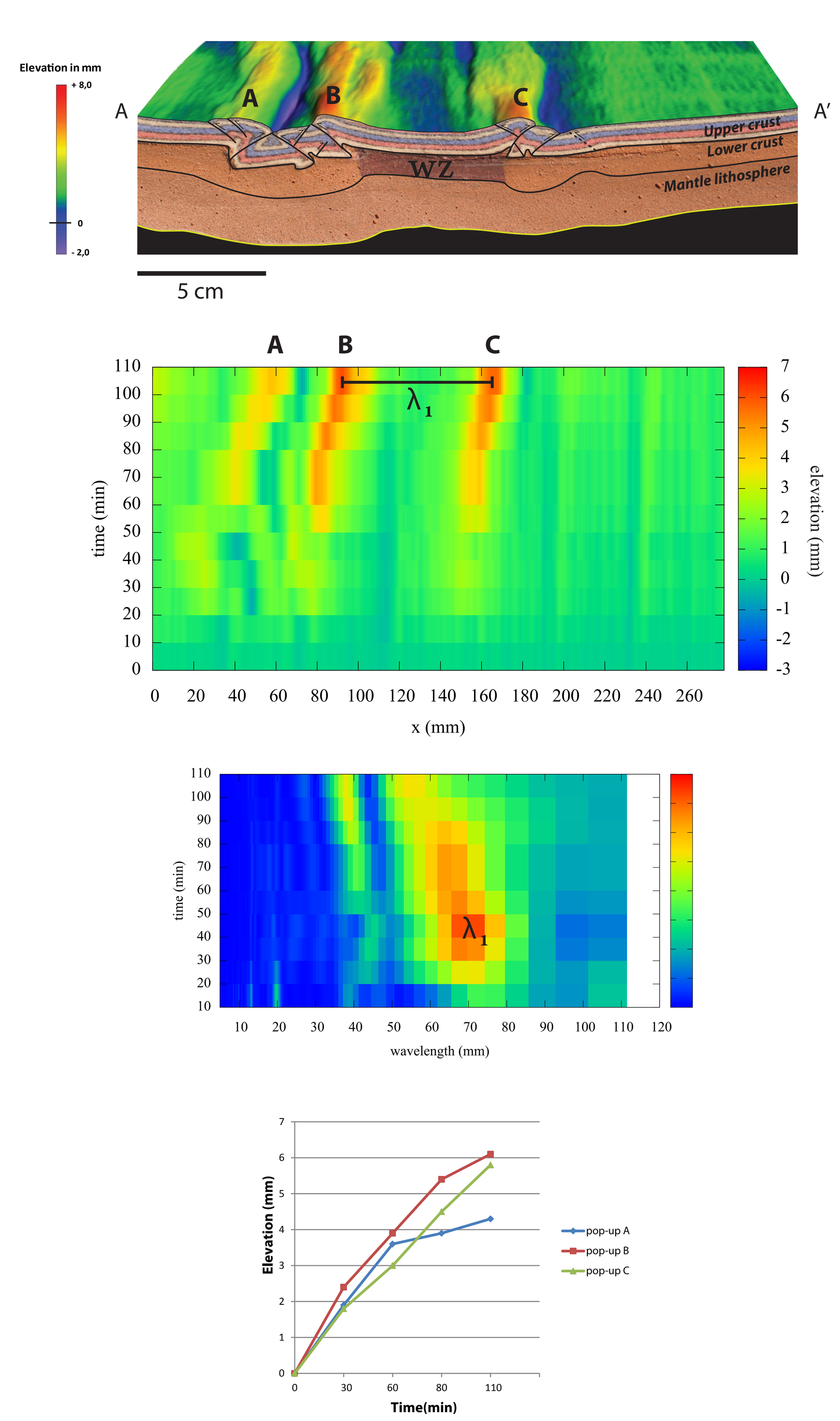
### Model 1

**Absence of a Disturbance Zone**



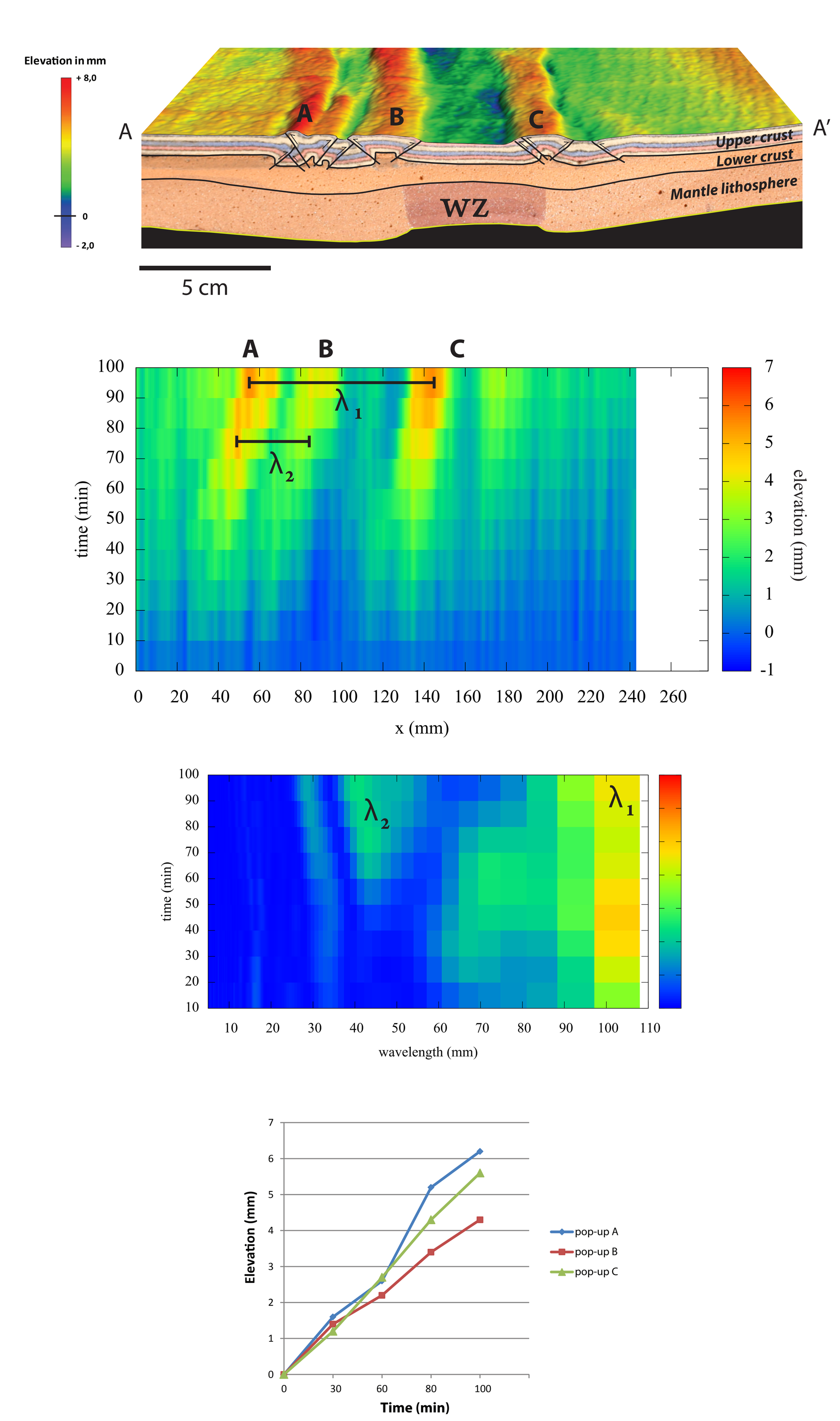

### Model 2

**Weak Zone in the lower crust**



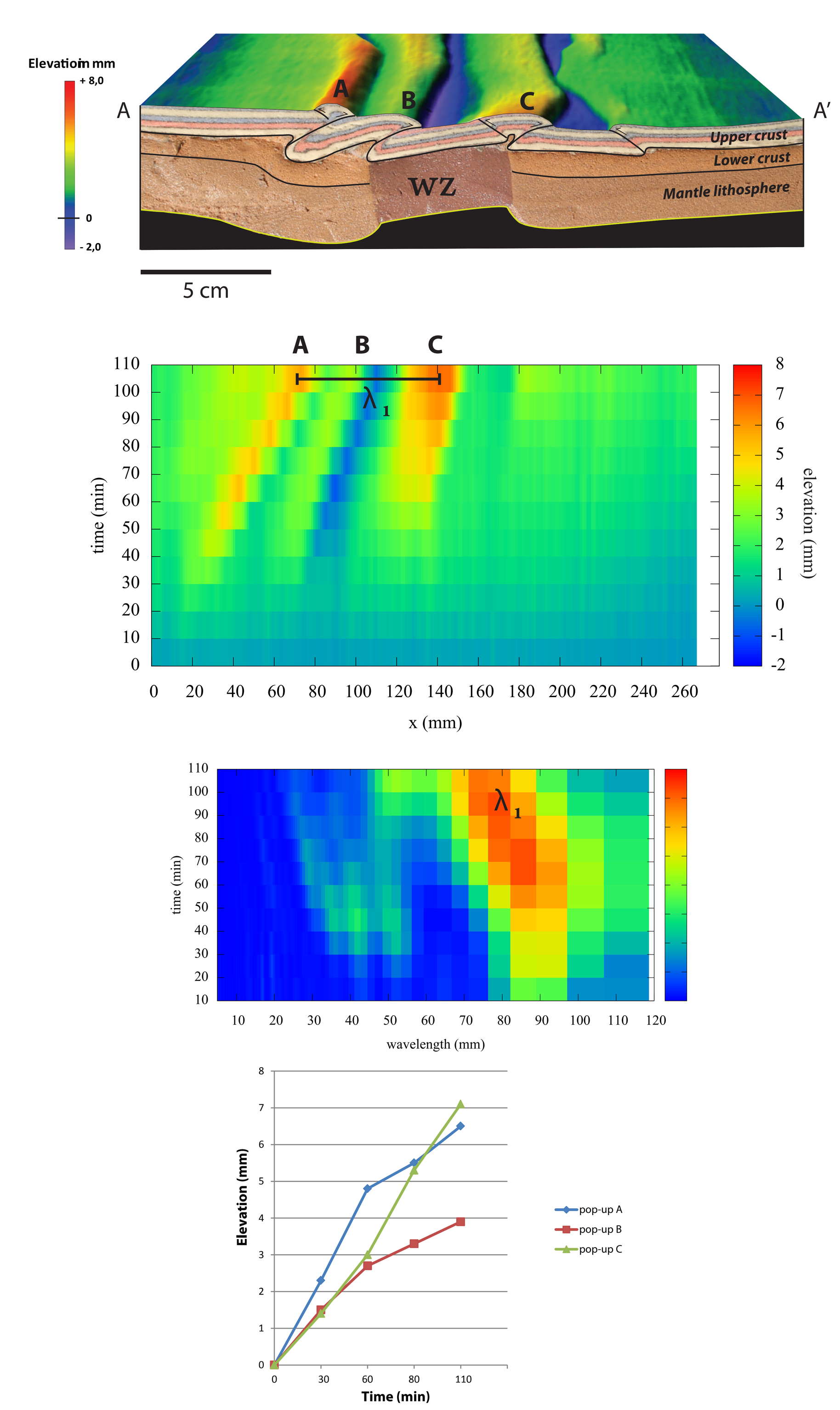

### Model 3

**Weak Zone in the upper mantle**




### Model 4

**Weak Zone in the lower crust & upper mantle**




### Model 5

**Strong Zone in the lower crust & upper mantle**

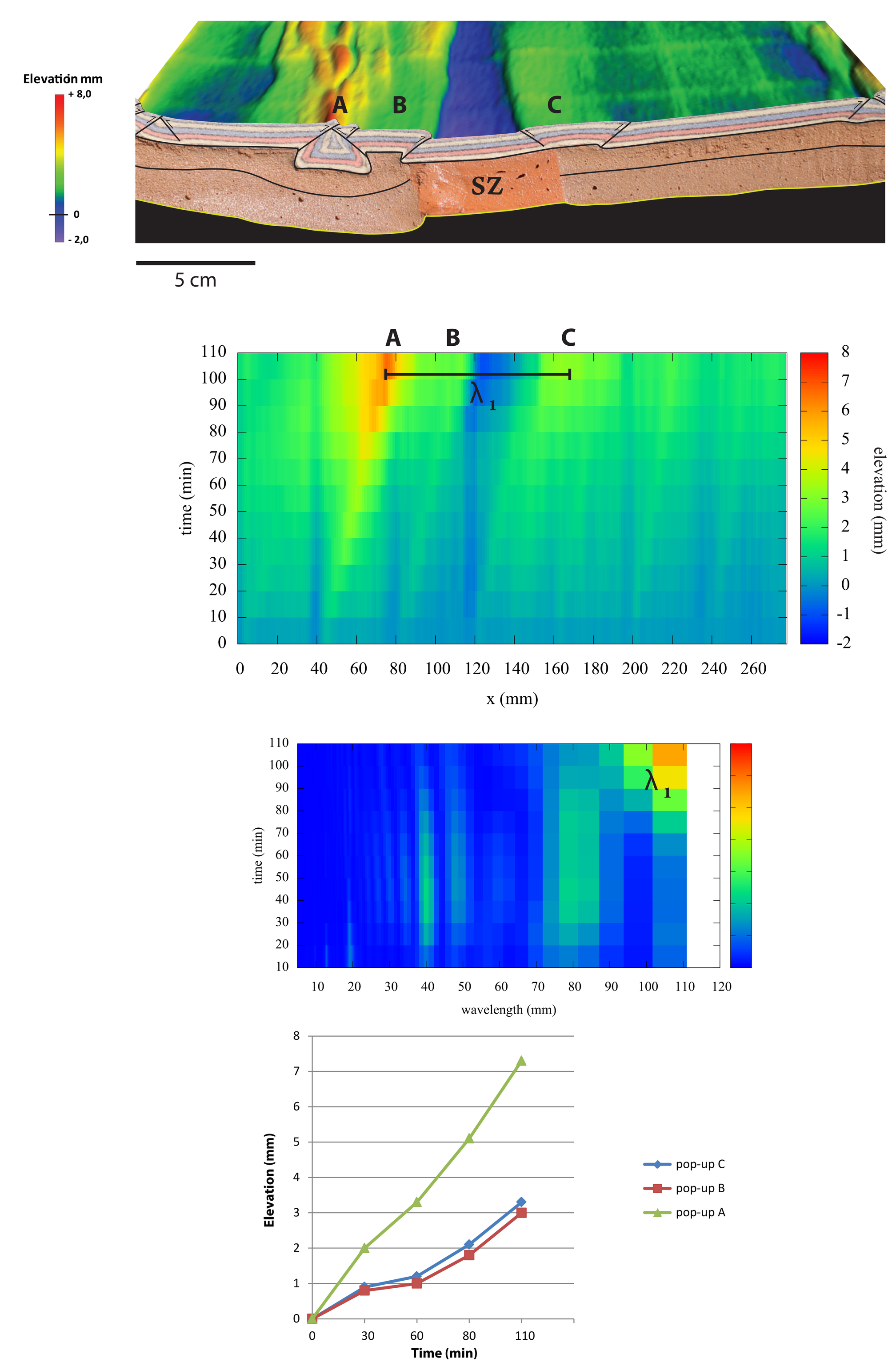



Figure 2: For each model from top to bottom: representative cross section and DEM (Digital Elevation Model) of the model surface at 20% BS; topography evolution in time; spectral analysis of topographic profile in time; plot of the uplift vs. time for the pop-ups A, B and C.

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